REPORT NUMBER: WI-16-99

FLOWABLE FILL AS BACKFILL FOR BRIDGE ABUTMENTS

FINAL REPORT

DECEMBER 1999

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
WI-16-99		

4. Title and Subtitle	5. Report Date
Flowable Fill as Backfill for Bridge Abutments	December 1999
	6. Performing Organization Code WisDOT Research Study # 99-05
7. Author(s) Joe Wilson	8. Performing Organization Report No. WI-16-99
9. Performing Organization Name and Address Wisconsin Department of Transportation DTID/BHC/Pavements Section/Technology Advancement Unit 3502 Kinsman Blvd. Madison, WI. 53704-2507	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Wisconsin Department of Transportation DTID/BHC/Pavements Section/Technology Advancement Unit 3502 Kinsman Blvd. Madison, WI. 53704-2507	13. Type of Report and Period Covered Final Report 10-1996 to 8-1999 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This study attempted to document the effectiveness of using a controlled low strength material (CLSM) as backfill for two county highway bridge abutments. The west ends of the two structures were constructed with the CLSM, while the east ends were constructed with conventional granular materials / compaction methods. The CLSM used consisted of a mixture of foundry sands, Class C flyash, cement and water. It was hoped that the CLSM would eliminate the familiar "dip" in the road experienced by roadway users at the bridge deck / approach interface caused by the settlement of the conventional materials / compaction methods. The two bridge abutments were constructed in the fall of 1996 and monitored for performance for three years. The evaluation consisted of taking levels of both sides of both structures twice a year and comparing the profiles for settlement.

In this case study, the data collected and plotted on graphs indicate that the abutments that were constructed with CLSM showed tighter groupings than the abutments constructed with conventional materials / compaction methods, i.e. the CLSM showed superior settlement characteristics. However, the difference is not real significant, but it is promising, and in the case of the CTH G bridge, the performance was noticeably better as rated by five adults riding in a 1998 Dodge minivan driven over the structure at normal highway speeds. The subjects were not told which side of the bridge was constructed with CLSM and which side was constructed with conventional methods. All agreed the CLSM side showed superior performance in terms of a less pronounced dip in the road at the bridge deck / approach interface. A similar poll conducted on the CTH D structure was inconclusive. It must be noted however, that both sides of both structures were patched with a 3/4 in. wedge of asphalt at one and two years after initial construction.

17. Key Words	18. Distribution Statement
flowable fill, backfill, bridge abutment, settlement, controlled low strength material, CLSM, profiles	

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price

FLOWABLE FILL AS BACKFILL FOR BRIDGE ABUTMENTS

Final Report

Research Study # 99-05
Report # WI-16-99

December 1999

By
Joe Wilson
Technology Advancement Specialist

WISCONSIN DEPARTMENT OF TRANSPORTATION
DIVISION OF TRANSPORTATION INFRASTRUCTURE DEVELOPMENT
BUREAU OF HIGHWAY CONSTRUCTION
PAVEMENTS SECTION
TECHNOLOGY ADVANCEMENT UNIT
3502 KINSMAN BLVD., MADISON, WI 53704-2507

TABLE OF CONTENTS

INTRODUCTION

In an effort to address and solve settlement problems at bridge abutments in a cost-effective way, the Wisconsin Department of Transportation experimented with flowable fill (Controlled Low Strength Material (CLSM)) as backfill for two bridge structures constructed in 1996. Flowable fill, a low-strength cementitious material, is thin enough to flow when placed, is self-leveling, and self-compacting. The flowable fill mixture consisted of foundry sand, fly ash, cement and water. The west ends of both structures were constructed with the flowable fill, while the east ends of the structures were constructed with conventional granular materials / compaction methods (see prints starting on page 17). Base course and pavement were then placed to complete the project. Evaluation consisted of taking levels and comparing the profiles for settlement. Pavement distress was also monitored for rutting and cracking etc. The two structures, located in southern Sheboygan County, Wisconsin, are on county trunk highways D and G (See Figures 1 and 2). These are low volume (430 for CTH D and less than 1000 for CTH G) roads.

INSTALLATION

CTH D (B-59-165)

The placement for the west abutment took place September 19, 1996. Ambient air temperature was 65° F. The original design dimensions to receive the fill were a depth of 5 ft. at the structure tapering to subgrade elevation at a distance of 25 ft. and containment on the sides by wingwalls constructed of natural soils and base course materials extending out from the wingwalls. However, due to rainy weather, 1-2 ft. of water was present in the trench. Granular backfill was used to "push" the water out, leaving the trench saturated. This was done to meet Department of Natural Resources (DNR) beneficial reuse requirements, which prohibits the placement of CLSM in standing water[1]. Thus the depth of the trench was reduced from 5 ft. to 3 ft. at the face of the abutment and extended for a distance of 15 ft. from the face of the abutment instead of the originally designed distance of 25 ft. The tapered design was used to minimize the potential effect of differential heaving between the conventional road base aggregates and the CLSM.

After the fill was placed (using standard ready mix trucks) to the correct elevation, a crown to match the bridge deck was constructed by placing extra fill at the centerline. The extra material placed at the centerline utilized less water in the mix in order to keep it from flowing away from the centerline. The finished surface of the fill was 9” to 10” below the surface of the bridge deck. A total of 45 yds. (5 ½ truck loads) of flowable fill was used. It was noted the consistency of the slurry varied somewhat between truck loads and that the first truckload appeared to be more fluid than the others.

The backfill material (¾” and 1 ½” road gravel) for the east abutment was placed in lifts and compacted with a plate compactor and a backhoe bucket. The east abutment was void of any standing water.

The K-C-1 mix design (by the Kohler Co.) consisted of 2500 lbs. of foundry sand from the Kohler Co., Sheboygan, WI.; 400 lbs. of Class C Fly Ash from Wisconsin Power & Light, Sheboygan; 50 lbs. cement and 85 gallons of water (approx. 709 lbs.) per ready mix truck. It was felt that the flowable fill for this abutment was too watery, thus the mix design for the CTH G structure was modified to use less water (83 gallons). The CLSM mix design and performance data are found in Tables 1 and 2 below.

Table 1 - CLSM Mix Design and Performance Data

Mixture	K-C-1
Foundry Sand (lbs/yd^3)	2500
Class C Fly Ash (lbs/yd^3)	400
Cement (lbs/yd^3)	50
Water (lbs/yd^3)	700
Water to Cement Ratio	1.55
Flow / Spread (inches)	8
Air Content (%)	2.5
Density (lbs/ft^3)	122
Compressive Strength (psi)	85 (@ 90 days)

Table 2- Summary of CTH D and CTH G

		CTH D	CTH G
Volume	(yd^3)	45	72
Water	(lbs/yd^3)	700	617
Bleed Water	(% of total)	2	1
Set-time	(hours)	24	(a)
Flow / Spread	(inches)	8	6
Compressive Strength		113*	176**

* - @ 90 days

** - @ 112 days

(a) - See CTH G discussion

During an on-site inspection on October 2, 1997 (13 days after placement) it was found that the flowable fill was not setting properly. There was a thin crust (1-2 in.) on top of the fill, but the material below the crust could easily be shoveled like packed granular material or fly ash that had been compacted and watered in embankment fills[3]. It's quite possible the excess water in the trench delayed the set time. It was also observed that the material had not been covered with base course and was exposed to air.

CTH G (B-59-166)

The placement for the west abutment for this structure took place on October 31, 1996. Ambient air temperatures were 30° - 35° F. with 20 mph winds. The site was prepared according to plan dimensions (five feet at the face of the abutment, tapering to subgrade elevation at 25 feet). The natural soils used for the berms to confine the flowable fill were silt to silty clay and were saturated due to recent heavy rains. Water was not present in the trench as was the case with CTH D. The first seven truck loads had a very good consistency. The last two truck loads were noticeably "looser". In all, 72 yds. of flowable fill were used for this abutment. Again, standard ready mix trucks were used to haul and effectively place the fill over the entire area of the trench. No spreading was necessary and the material flowed well. As with the CTH D project, an attempt was made to match the crown of the structure by placing more material at the centerline. A *modified* slump test was performed on the second truck load and the result was 11 inches of spread. As noted earlier, the mix design for this fill utilized less water than that used for the CTH D which was thought to be too watery.

The water was heated at the plant to give a faster set. It was estimated that the temperature of the flowable fill when delivered at the site was 70°- 80° F. Due to low air temperatures (30° - 35° F.), the flowable fill was covered with plastic and straw in an attempt to aid set-up. The sheet of plastic used was 20 ft. wide and the fill area was 30 ft. wide, so the plastic was centered over the roadway leaving 5 ft. of flowable fill exposed on the outside edges.

As of November 12, 1996 (12 days after placement), the flowable fill was still mushy and had not set completely. In addition, trucks hauling base course gravel had rutted the flowable fill. Thus, the top one foot of moist material was removed and covered with a geotextile R fabric and an extra one foot of gravel to enable the contractor to pave the approaches. This reduced the length of the flowable fill area from 25 ft. to 20 ft and resulted in a base course two feet thick for this end of the structure.

It appears that the cold weather and the saturated surrounding soils significantly lengthened the set time. The cold temperatures likely reduced the rate of hydration and the saturated surrounding silty / clay soils may have prevented the release of moisture from the CLSM. In addition, the plastic covering that was used with the intent of keeping the heat in the mix to increase the rate of hydration may have actually contributed to the delayed set time by inhibiting the release of moisture from the CLSM.

As stated above, the amount of water for the mix was reduced to shorten the set time in anticipation of cold temperatures. This resulted in the higher compressive strength (176 psi @ 112 days).

The east abutment was completed prior to the flowable fill placement. The bank run material intended for use here was thought to be too fine (fine sand with silt), so base course (1 ½ in. & ¾ in. road gravel) material was used.

PROFILES

Levels were taken at the centerline and the edge lines of both approaches (east and west) for the two structures. The ends of the structure / bridge were considered a distance of 0.0 ft. Measurements were taken at 1 ft. and then continued at 4 ft. intervals to 25 ft. Measurements were then continued to the end of the new asphalt approaches at 10 ft. intervals (to 85 ft. for CTH D, 100 ft. for CTH G). A base line profile was taken of the approaches on November 19, 1996. It should be noted that there were approximately 15 days of freeze / thaw cycles in that area of the State that fall prior to the baseline profiles. This may have resulted in a "higher" baseline profile elevation -wise due to the effects of frost-heaving. Profiles were done again on February 3, 1997, August 25, 1997, August 12, 1998, March 22, 1999 and August 23, 1999. The profiles of the four approaches were then plotted to determine whether or not any movement / settlement had occurred. After plotting the data, the decision was made to omit the February and March data from the graphs due to the effect of frost heaving. This reduced the "clutter" some so that the long term effect of settlement would be more clearly apparent. See the graphs on pages 13 - 16 below.

After 10 - 11 months, there did not appear to be any great difference in performance between the granular backfill and the flowable fill. There appeared to be some slight settling at bridge/approach transition at the CTH D structure. This may have been due to the high water table at this site. In addition, the design dimensions to receive the flowable fill were reduced at this site due to the excess water that was present in the trench.

Both ends of both structures were patched with a ¾ inch thick wedge of asphalt in October of 1997 and again in October of 1998 due to settlement of the approaches to the bridge decks. These patches extended approximately 12 - 14 in. out from the edge of the bridge decks, except the patch on the east end of the CTH D structure which extends out approximately 1 - 3 ft.

PAVEMENT PERFORMANCE OF THE APPROACHES

3-4 Month Survey (February 3, 1997)

No cracking was present at the approaches of both structures. Scrape marks from snowplows were noted at the transition of the bridge deck to the approach at the CTH G bridge. Plow scraping was also noted at the west end of the CTH D bridge at the centerline in the transition of the bridge deck to the approach.

10-11 Month Survey (August 25, 1997)

There were no cracks at the approaches of both bridges. Some slight rutting was observed at the CTH G structure approaches. Approximately 0.1 ft. of rutting at the east end and less than 0.1 ft. at the west end of the CTH G structure. Measurements were taken in the wheel paths. No rutting was present at the CTH D structure.

34-35 Month Survey (August 21, 1999)

CTH G

The concrete bridge deck was in excellent condition and void of any cracking. The paved approaches were in good condition except for some slight rutting. There was one 15 ft. long longitudinal crack on the south shoulder of the east approach. This crack was 23 ft. from the edge of the bridge deck. The asphalt patches placed in the fall of 1997 and 1998 were limited to the driving lanes, i.e. the paved shoulders were not patched. It was observed that the shoulders have settled with the south east shoulder approximately 0.75 in. below the bridge deck and the southwest shoulder approximately 2.0 inches below the bridge deck. The northeast and northwest shoulders did not show quite as much settlement, perhaps due to the sloping super elevation of the road.

CTH D

The concrete bridge deck was in excellent condition with no cracks. The pavement itself was void of any cracking distress, however some moderate rutting had occurred on both approaches.

DISCUSSION / INCIDENTALS

The success of this particular project largely depended on whether or not the use of CLSM eliminated backfill material consolidation / settlement at the bridge abutments, i.e., the familiar dip and thump experienced by drivers at bridge abutments. However, even if the total performance is not better than the conventional method for backfilling bridge abutments, and if the performance is at least as good, using and placing flowable fill may realize some savings as it cuts down on construction steps (compaction and labor). In addition, waste foundry sands and fly ash that otherwise would have been landfilled were reused, thus preserving finite virgin aggregates and sands for future uses.

A major advantage of using CLSM is that the need to compact the material is eliminated thus saving time, money and labor. The CLSM also provides an opportunity for the beneficial reuse of recovered / waste materials for the filler aggregate(s).

RESULTS / CONCLUSIONS

From the available data, it appears that the use of flowable fill as backfill for both of these structures performed slightly better than the conventional granular fill, however the difference is not significant. The results though, are promising enough to continue this research on other project(s) granted that lessons learned are applied. A literature search discovered a similar project that reported flowable fill to have superior settlement properties under heavy traffic loading as compared to conventional backfill[3].

A “seat of the pants” opinion poll was conducted on November 3rd , 1999 to rate the relative performance of the flowable fill vs. the conventional granular backfill construction methods of the CTH G structure. Five adult passengers in a 1998 Dodge minivan were asked to rate the relative severity of the “dip” in the road experienced as one drives over the structure, first from one end and then from the other end at normal highway speeds (50 mph in this case). The subjects were not told which side of the bridge used the flowable fill and which side used conventional granular materials. The consensus results were unanimous in that all five passengers rated the side of the bridge that used the flowable fill as having superior settlement performance, i.e. the dip experienced at the face of the structure was less pronounced than the dip experienced on the side of the bridge where conventional granular backfill materials / compaction methods were used. A similar poll conducted on the CTH D structure was inconclusive, there was not any noticeable difference between the two sides. It should be noted that the ride could be influenced by the paving operation and / or the asphaltic mix used (some rutting did develop). This must be kept in mind when evaluating the ride as it relates to any settlement.

It was thought that the plastic sheet used to cover the flowable fill on the CTH G structure to aid in the rate of hydration may have actually prevented the material from breathing, thus preventing the release of moisture from the CLSM. The soils surrounding the fill area were silty, silty clay and may also have contributed to the problem. Perhaps by limiting the placement of this material to the summer months or when temperatures are not expected to drop below 40° - 45° F. for several days would avoid this problem (set-up) altogether.

On the CTH D structure, the standing water in the trench that received the flowable fill may have “skewed” the results.

On the CTH G structure, the top one foot of CLSM was removed because it hadn’t set up completely. A geotextile R fabric and an extra one foot of base course (2.0 feet total) was then placed on top of the CLSM to enable the contractor to pave the approaches. The results from this structure may be “skewed” as well.

RECOMMENDATIONS

1.) It is recommended that for future endeavors, more levels be taken. Specifically, for each approach, in addition to taking 3 levels (one for the centerline and one each for the edge lines), a total of 9 should be taken to include left and right wheel paths of both lanes and the center of each lane. A contour map could then be made from the data points to better see the settlement patterns for comparison purposes.

2.) It is recommended that future projects limit the placement of flowable fill to the summer months to prevent cold / freezing temperatures from delaying or preventing good set up of the material.

3.) Any change in the water content of the mix needs to be “counter balanced” with a decrease in the amount of cement to avoid higher than desired compressive strengths.

4.) In future projects that have standing water due to higher than anticipated water levels / rainy weather, perhaps a lower layer of washed stone on top of granular material to absorb excess water could be tried[2]. Another approach may be to limit the placement of the flowable fill so as to be above the “typical” high water mark / level.

5.) Consistency between truck loads of CLSM (with the same mix design) seems to be a recurring issue with WisDOT construction personnel. Further investigation into this problem is recommended. Perhaps more care should be taken in removing excess water from the ready mix trucks between loads. Consistency affects spread, compressive strength, set time etc.…

6.) It is recommended that another project be identified to carry this research further, specifically on a replacement bridge as opposed to new construction. This should ensure that the subbase or in situ materials have settled completely with time. In addition, it is recommended that the area selected should be such that the native soils are more “cohesive” such as clay as opposed to an area where the soils are more sandy / gravely. This was recommended by WisDOT district 3 personnel because their experience has been that settlement problems are associated more with areas where the surrounding soils have more clay or cohesive materials than in areas that are predominantly sandy / gravely. The promise is there for improved performance, granted that lessons learned from this project (and other research study results / recommendations) are applied.

CTH D and CTH G Summary

	CTH D	CTH G
Mix Design Data		
Volume (yd3)	45	72
Water (lbs. / yd^3)	700	617
Foundry Sand (lbs. / yd3)	2500	2500
Class C Fly Ash (lbs. / yd3)	400	400
Cement (lbs. / yd3)	50	50
Water to Cement Ratio	1.55	1.55
Air Content (%)	2.5	2.5
Density (lbs. / ft^3)	122	122
Bleed Water (% of total)	2	1
Set Time (hours)	24	See CTH G discussion
Flow / Spread (inches)	8	11
Compressive Strength	113 @ 90 days	176 @ 112 days
Air Temp. @ Placement Time	65^o F. September 19, 1996	30^o - 35^o F. October 31, 1996
		(The fill was covered with plastic & straw to aid the set-up.)
Construction Particulars	Water was present in the trench and thus an attempt was	Water was *not* present in the trench.
	made to use granular backfill to "push" the water out of the	
	trench. This reduced the design dimensions from 5 ft. at the	The natural soils used for the berms to confine the fill
	face of the abutment to 3 ft. and also reduced the length of	were silt to silty clay and were saturated by recent rains.
	the taper extending out from the abutment from 25 ft. to 15 ft.	
		12 days after placement the fill was still mushy & had not
	The granular backfill material (¾" and 1 ½" road gravel) for	set completely. In addition, trucks hauling base course
	the east abutment was placed in lifts and compacted with a	gravel had **rutted** the flowable fill. Thus, the top one foot
	plate compactor and a backhoe bucket.	of moist material was removed and covered with a **geo-**
	The east abutment was void of any standing water.	**textile R fabric** and an extra one foot of gravel.
		This reduced the length of the flowable fill area from 25 ft.
	3/4 in. asphalt wedge placed on both ends at 1 and 2 yrs.	to 20 ft and resulted in a **base course two feet thick.**
	after initial construction.	
		3/4 in. asphalt wedge placed on both ends at 1 and 2 yrs .
	Structure sited on low wetland, closer to water level than CTH G	after initial construction.
	which is situated on higher ground, further up from the creek level.	
Performance Summary	Performance is inconclusive in terms of ride, i.e. the familiar "dip"	Flowable fill side performing better than the side that used
	experienced at the face of the bridge deck is about the same for	conventional materials / compaction methods in terms of ride,
	both abutments when driven over at normal highway speeds.	i.e. less pronounced "dip" at bridge face as drive over.

Figure 1.

FLOWABLE FILL AS BACKFILL FOR BRIDGE ABUTMENTS

CTH D Bridge (B-59-165)

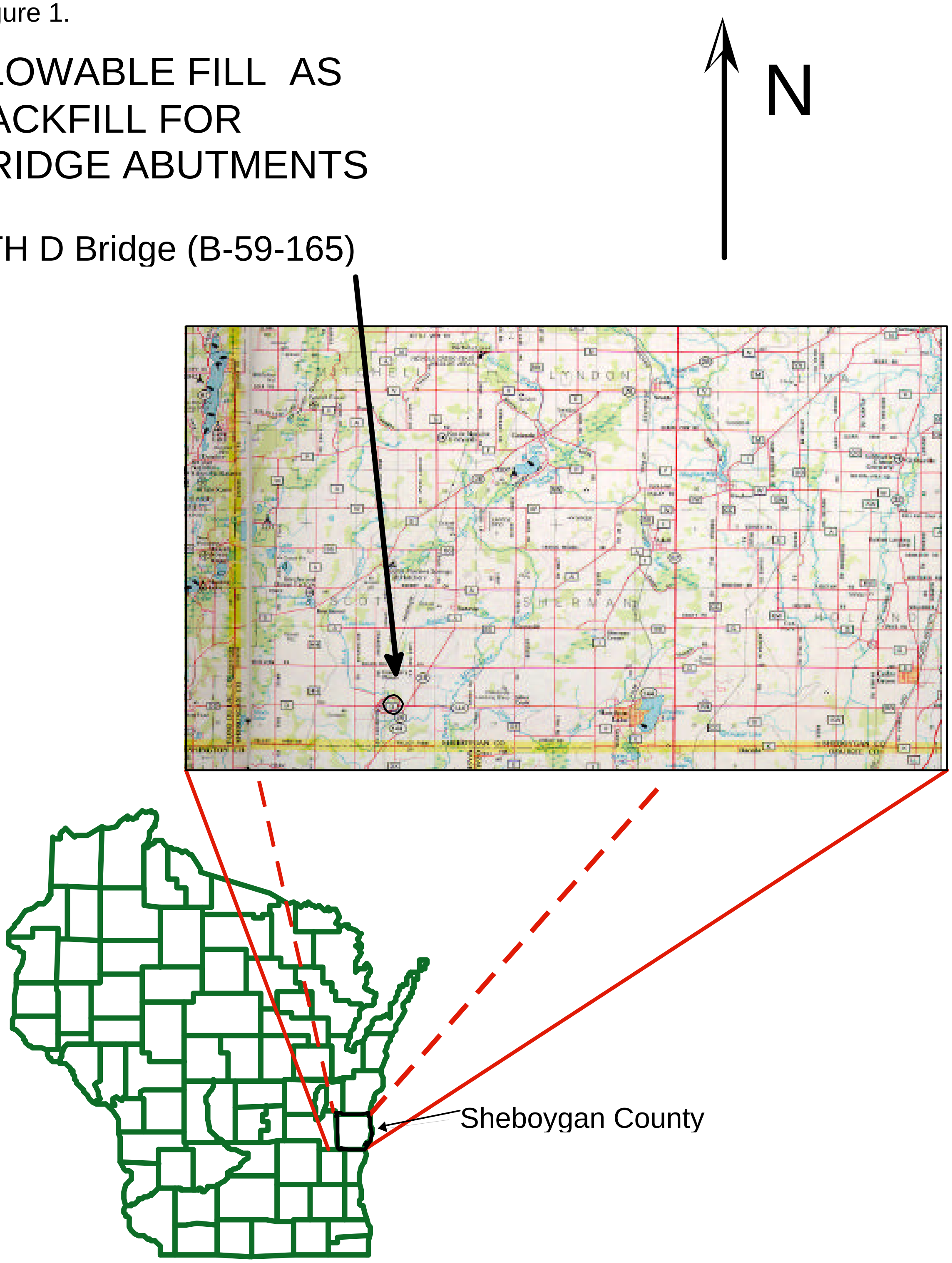
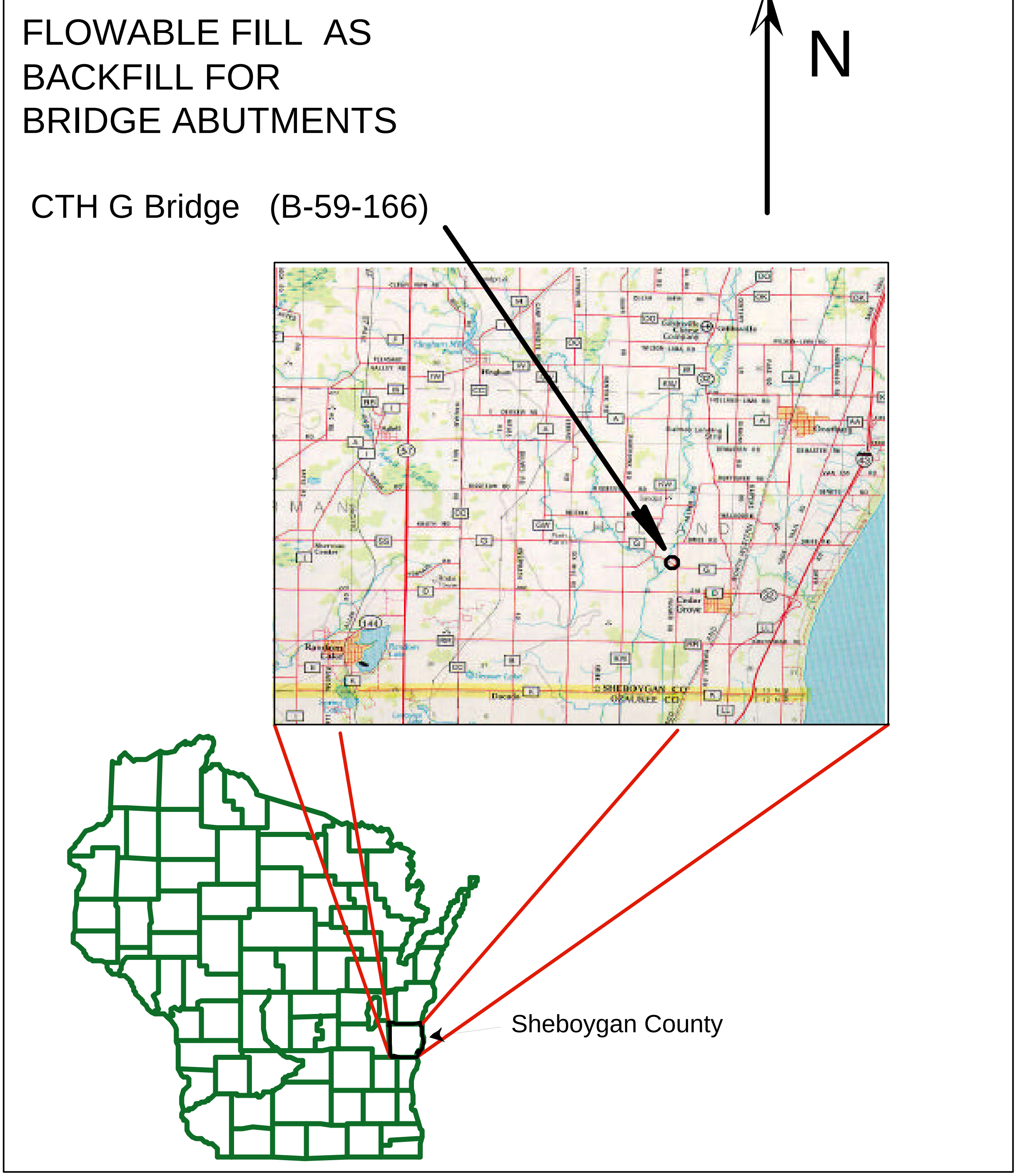
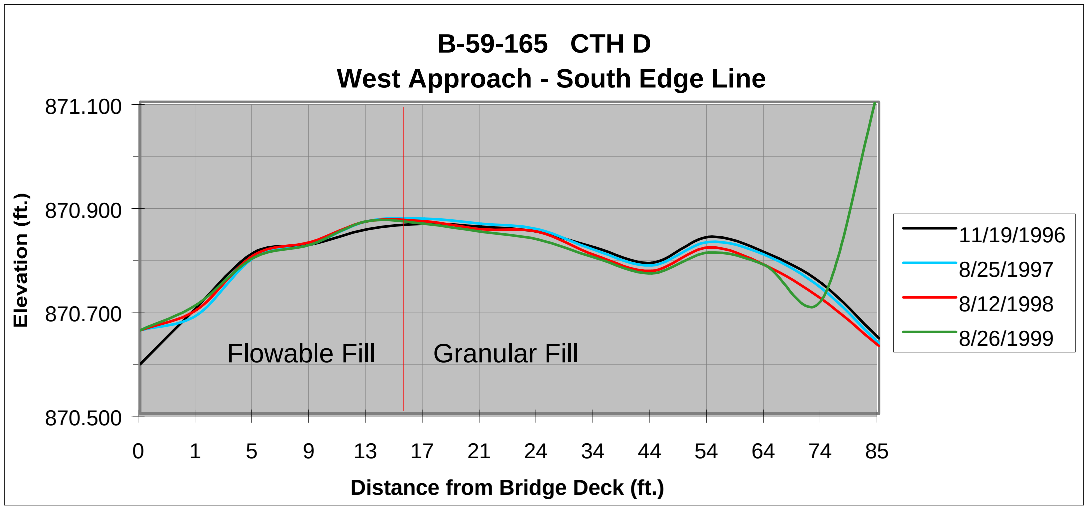
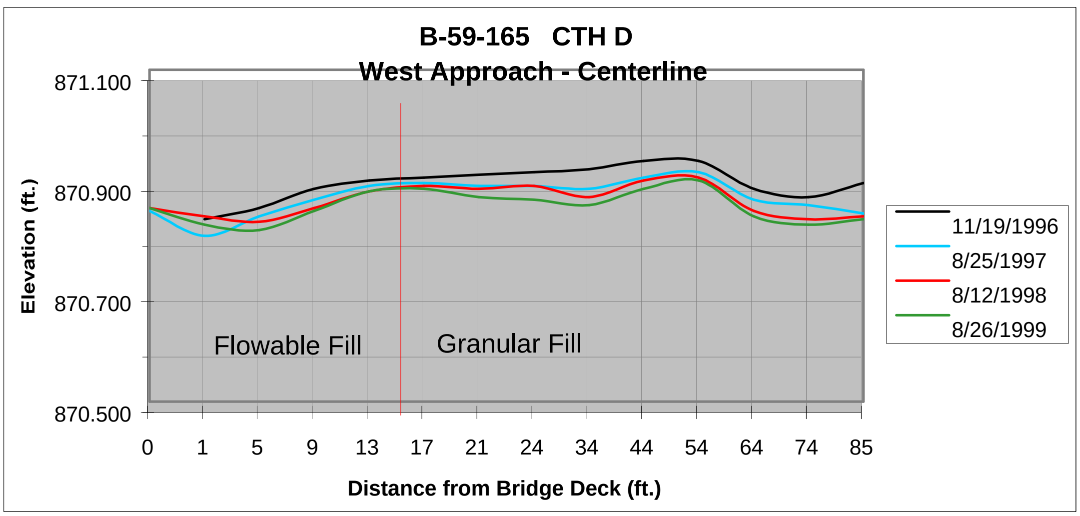
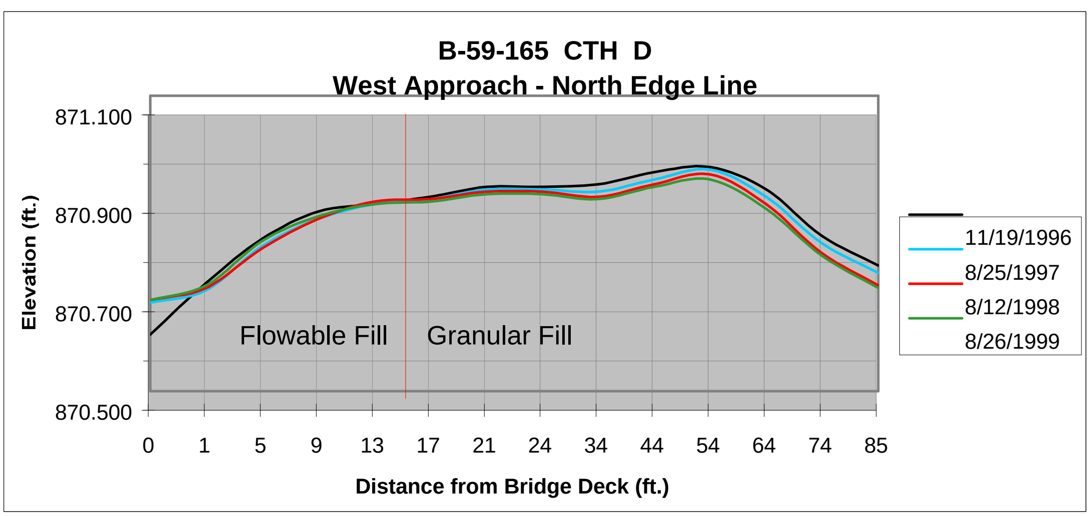


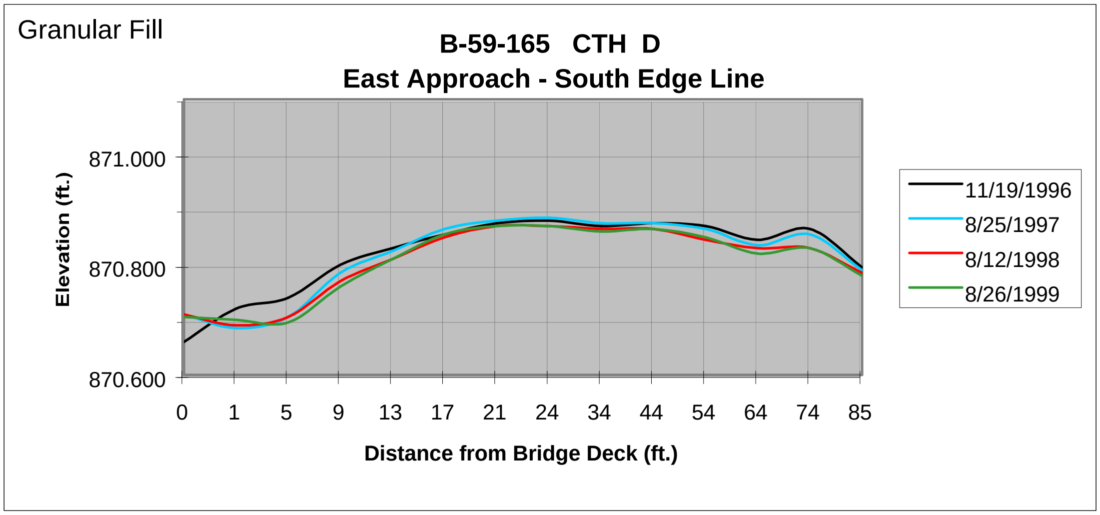
Figure 2.

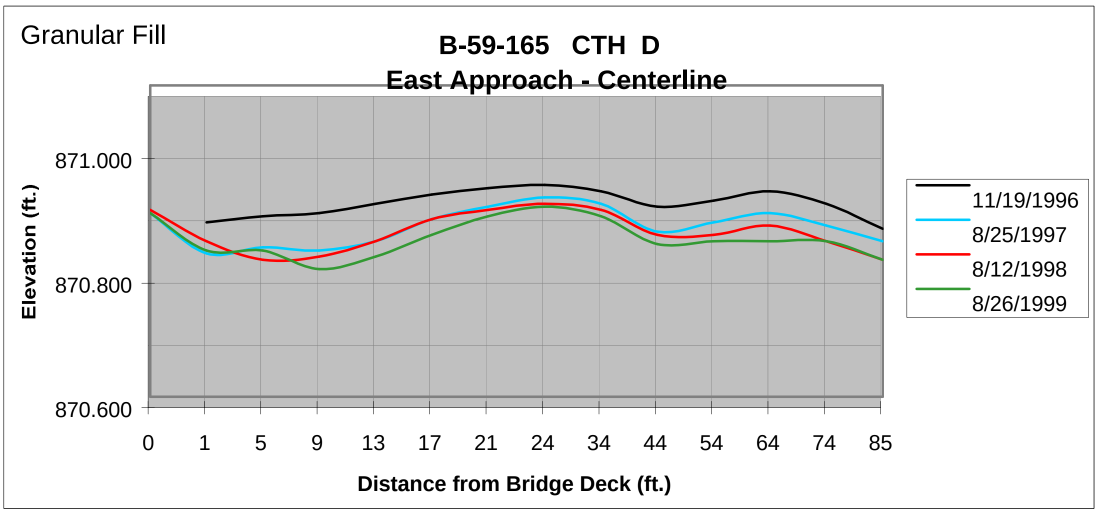

FLOWABLE FILL AS
BACKFILL FOR
BRIDGE ABUTMENTS
CTH G Bridge (B-59-166)
N
Sheboygan County

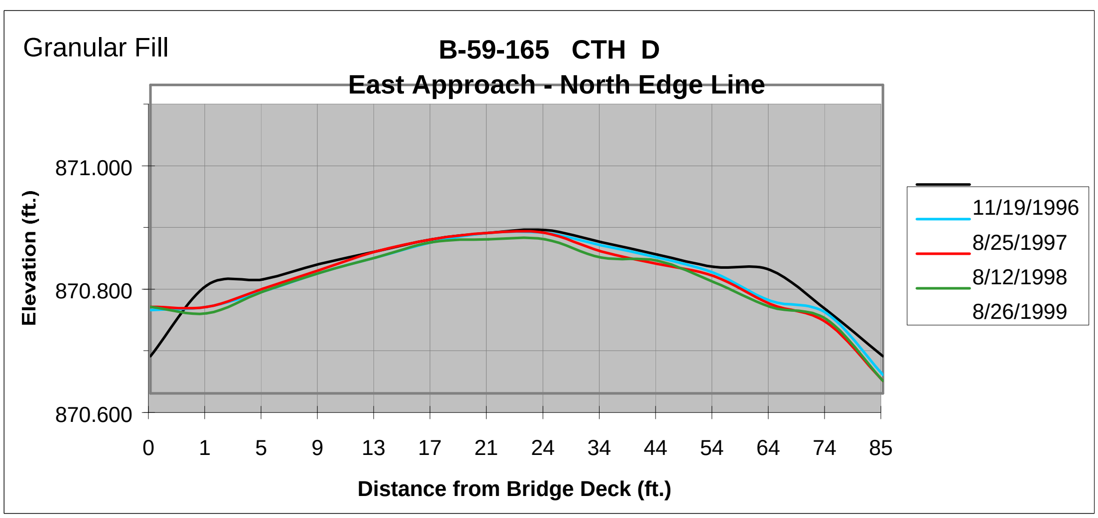

B-59-165 CTH D
West Approach - South Edge Line
871.100
870.900
870.700
870.500
Elevation (ft.)
Flowable Fill
Granular Fill
0
1
5
9
13
17
21
24
34
44
54
64
74
85
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/26/1999

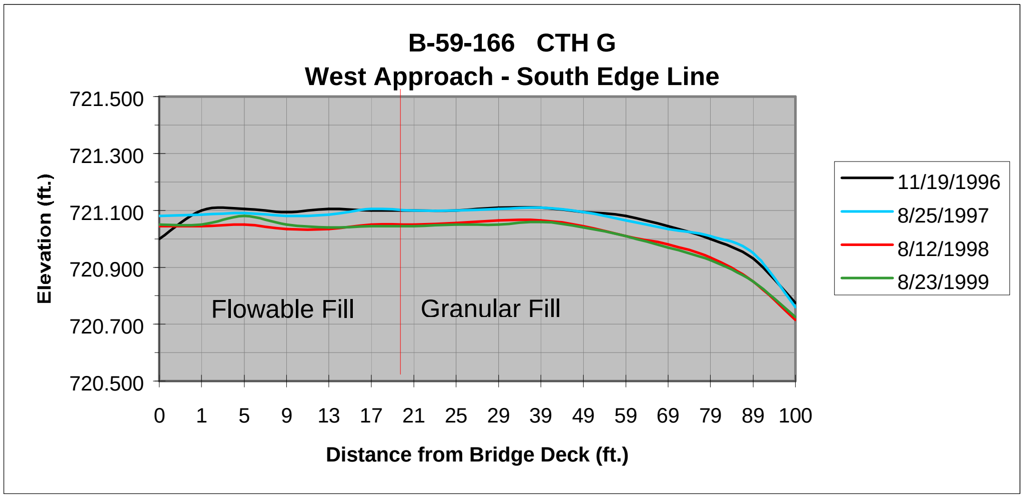

B-59-165 CTH D
West Approach - Centerline
871.100
870.900
870.700
870.500
Elevation (ft.)
Flowable Fill
Granular Fill
0
1
5
9
13
17
21
24
34
44
54
64
74
85
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/26/1999

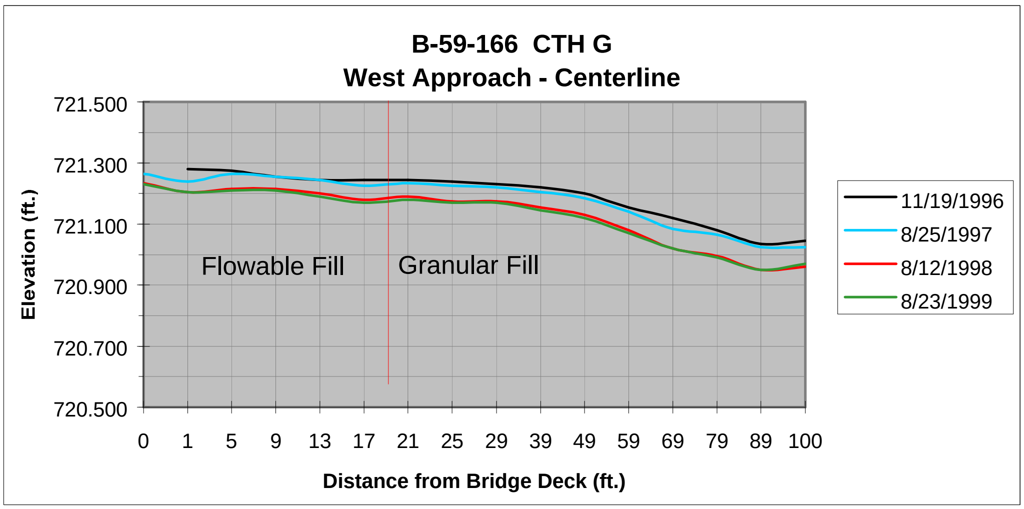

B-59-165 CTH D
West Approach - North Edge Line
871.100
870.900
870.700
870.500
Elevation (ft.)
Flowable Fill
Granular Fill
0
1
5
9
13
17
21
24
34
44
54
64
74
85
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/26/1999

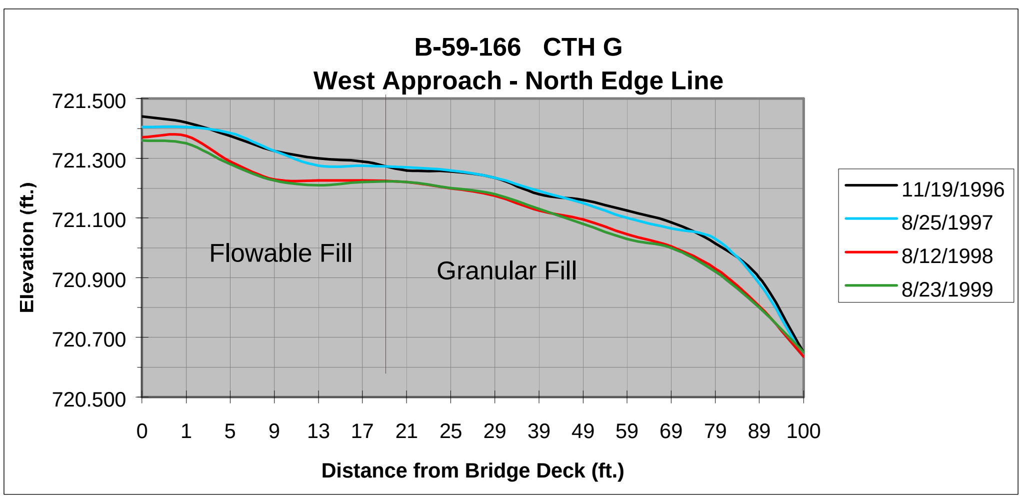

Granular Fill
B-59-165 CTH D
East Approach - South Edge Line
Elevation (ft.)
871.000
870.800
870.600
0 1 5 9 13 17 21 24 34 44 54 64 74 85
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/26/1999

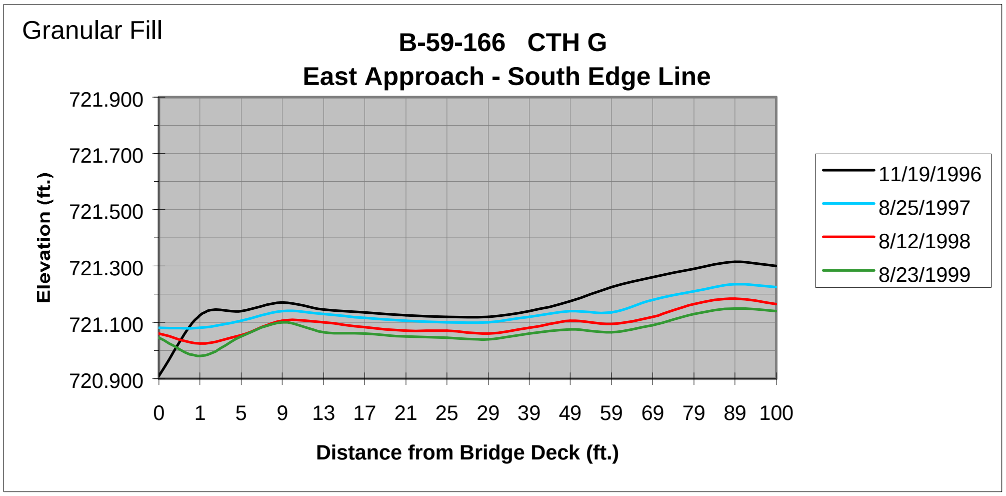

Granular Fill
B-59-165 CTH D
East Approach - Centerline
Elevation (ft.)
871.000
870.800
870.600
0 1 5 9 13 17 21 24 34 44 54 64 74 85
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/26/1999

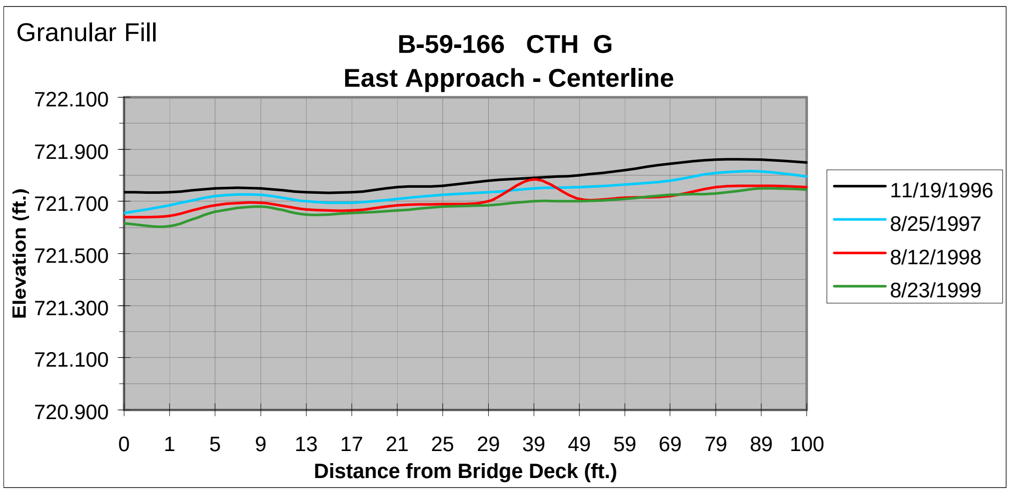

Granular Fill
B-59-165 CTH D
East Approach - North Edge Line
Elevation (ft.)
871.000
870.800
870.600
0 1 5 9 13 17 21 24 34 44 54 64 74 85
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/26/1999


B-59-166 CTH G
West Approach - South Edge Line
721.500
721.300
721.100
720.900
720.700
720.500
Elevation (ft.)
Flowable Fill
Granular Fill
0 1 5 9 13 17 21 25 29 39 49 59 69 79 89 100
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/23/1999


B-59-166 CTH G
West Approach - Centerline
721.500
721.300
721.100
720.900
720.700
720.500
Elevation (ft.)
Flowable Fill
Granular Fill
0 1 5 9 13 17 21 25 29 39 49 59 69 79 89 100
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/23/1999


B-59-166 CTH G
West Approach - North Edge Line
721.500
721.300
721.100
720.900
720.700
720.500
Elevation (ft.)
Flowable Fill
Granular Fill
0 1 5 9 13 17 21 25 29 39 49 59 69 79 89 100
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/23/1999


Granular Fill
B-59-166 CTH G
East Approach - South Edge Line
721.900
721.700
721.500
721.300
721.100
720.900
Elevation (ft.)
0 1 5 9 13 17 21 25 29 39 49 59 69 79 89 100
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/23/1999


Granular Fill
B-59-166 CTH G
East Approach - Centerline
722.100
721.900
721.700
721.500
721.300
721.100
720.900
Elevation (ft.)
0 1 5 9 13 17 21 25 29 39 49 59 69 79 89 100
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/23/1999

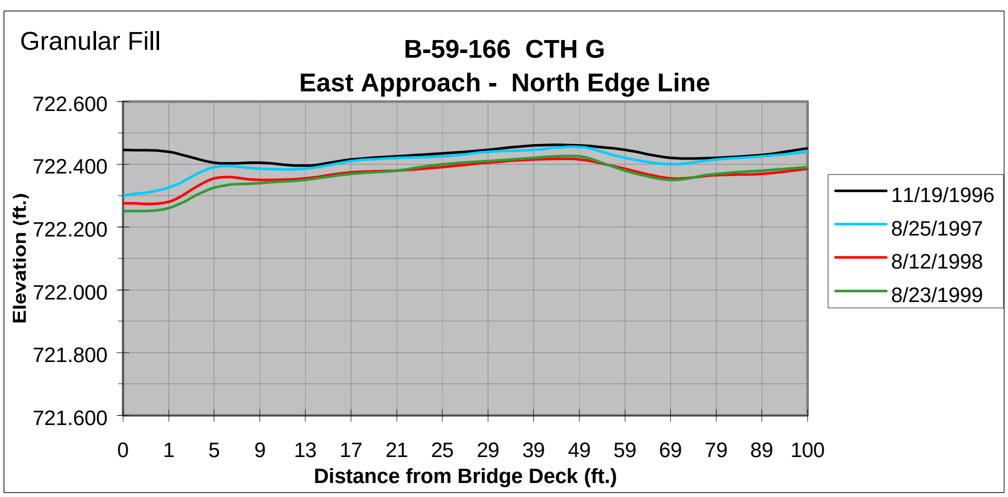

Granular Fill
B-59-166 CTH G
East Approach - North Edge Line
722.600
722.400
722.200
722.000
721.800
721.600
Elevation (ft.)
0 1 5 9 13 17 21 25 29 39 49 59 69 79 89 100
Distance from Bridge Deck (ft.)
11/19/1996
8/25/1997
8/12/1998
8/23/1999

Photo courtesy of the Kohler Co.

Print 1 - CTH D (Mink Creek) West bridge abutment. Notice standing water in trench.

Photo courtesy of the Kohler Co.

Print 2 - CTH D West bridge abutment after conventional aggregate used to “remove” standing water.

Photo courtesy of the Kohler Co.

Print 3 - CTH D Showing placement of the CLSM.

Photo courtesy of the Kohler Co.

Print 4 - CTH D   Showing completion of the CLSM placement.

Photo courtesy of the Kohler Co.

Print 5 - CTH D Looking East, CLSM @ 3 days after placement.

Photo courtesy of the Kohler Co.

Print 6 - CTH D   CLSM excavatable @ 3 days.

Photo courtesy of the Kohler Co.

Print 7 - CTH G (Onion River) Showing west abutment site preparation.

Photo courtesy of the Kohler Co.

Print 8 - CTH G   Showing placement of the CLSM on the west abutment.

Photo courtesy of the Kohler Co.

Print 9 - CTH G Showing the removal of the top 1.0 ft. of CLSM that didn't set.

Photo courtesy of the Kohler Co.

Print 10 - CTH G After 1.0 ft. of CLSM removed.

Print 11 - CTH D - East abutment patch.

Print 12 - CTH D - East abutment in foreground.

Print 13 - CTH D - West abutment.

Print 14 - CTH D - West abutment patch.

Print 15 - CTH G - East abutment in foreground.

Print 16 - CTH G - East abutment patch.

Print 17 - CTH G - West abutment patch.

Print 18 - CTH G - West abutment south shoulder not patched.

REFERENCES

1. Spoerl, John and Green, Tom; "Beneficial Reuse of Foundry Sand in Controlled Low Strength Materials (CLSM)"; Final Report, Demonstration Grant #95-60; The Kohler Co.; February, 1997.

2. Hanzel, Ken; Wisconsin Department of Transportation District 3, Chief Soils Engineer.

3. Gress, David; "The Effect of Freeze-Thaw and Frost Heave on Flowable Fill"; University of New Hampshire; October 1996.